METHOD AND APPARATUS FOR GENERATING AN ANGULAR SWEEP OF A DIRECTED PROPAGATION OF ELECTROMAGNETIC RADIATION

This application claims the benefit of United States Provisional Application no. 60/227,332, filed August 23, 2000.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to creating a sweep of a directed propagation of electromagnetic radiation, for example, a beam of light, a laser or microwave energy. Specifically, the present invention relates to generating a sweep by amplifying the effect of a first movable reflector through repeated reflections back to the first reflector by a fixed reflector.

Description of Related Art

Beam sweeping is used, for example, in machine readable symbology scanning devices, for example bar code readers. A beam sweeping across a bar code is reflected back to the scanner where variations in the reflected light is detected, corresponding to the bar code. The sweep angle of the beam determines the range from and width of a code that may be scanned. Frequency of the sweep is a factor in determining the time necessary for a scan. The reading and the decoding of machine readable symbologies is commonly performed by two methods, discussed below. Available devices commonly function with a light or

other electromagnetic radiation source and a radiation sensitive sensor, responsive to the source wavelength, allowing the detection of the variations in the reflection of the illuminated bar code.

The first method, for information, uses light concentrated in the zone of the code to be read, and a sensor CCD which converts the reflected light into electric information. Where the zone of the code is sequentially illuminated by a sweeping beam, the reflected beam may be detected and compared to the known location of the beam over a full sweep of the zone and a 2D image thereby captured for further decoding/processing.

The second method utilizes focused lighting, for example a laser beam - which oscillates left and right in a plane, and which collects the variations of light reflected on the bar codes with a photodiode. To obtain a focused laser beam which sweeps space according to an angle of approximately 20° to 40°, previous devices use either revolving mirrors to reflect a beam or a single oscillating reflector device with a large amplitude.

A revolving mirror device requires an electric motor, which consumes a large amount of energy, limiting battery life or requiring a fixed power connection. The energy is required to overcome the aerodynamic turbulence around the wheel with the mirror, which must spin at a very high velocity to achieve an acceptable sweeping frequency. The sweep angle generated by a rotating mirror is fixed by the number of mirror faces on the rotating assembly and is not modifiable after

manufacture. One advantage of the revolving mirror is that the speed of the mirror may be adjustable, allowing the sweep frequency to be variable. However, revolving mirror scanners require a mechanical assembly which is bulky, in opposition to the trend of miniaturization with modern scanners. The rotating mirror type of mechanism also generates a noise, some vibration, and even a prejudicial gyroscopic effect noticeable by a user of the device.

Oscillating reflector devices with a large amplitude achieve the full sweep of the beam from the single oscillating reflector. By oscillating at a resonance frequency derived from the physical design characteristics of the reflector, this solution has the advantage of consuming little energy while at the resonance frequency. A useable sweep is generated by a plane mirror intercepting the laser beam, assembled on a system which is mechanically resonant and is maintained in resonance by electromagnetic energy. The amplitude of the vibration can be controlled, thereby adjusting the sweep angle but the sweep frequency is for practical purposes (energy consumption and MTBF) set by the resonance frequency resulting from the mechanical design.

The reading of bar codes with a sweeping laser beam requires a significant angular amplitude, the principle described hereafter makes it possible to reduce the amplitude of angular oscillation/vibration of the reflective moving element, without a corresponding reduction in final sweep angle.

It is an object of the present invention to provide a method and apparatus with low energy consumption, variable sweep angle and or sweep frequency without the problems and or limitations associated with the prior art. Further objects will be realized by one skilled in the art upon a review of the descriptions, figures and claims herein.

SUMMARY OF THE INVENTION

An angular sweep of a directed propagation of electromagnetic radiation is generated by a first oscillating or vibrating reflector that cooperates with at least one fixed reflector. Electromagnetic radiation incident upon the first reflector is reflected to the fixed reflector with a sweep created by movement of the first reflector and in turn is reflected back to the first reflector at least once, each reflection back to the first reflector approximately doubling again the angular sweep created by the previous reflection from the first reflector. Multiple reflections create a wide angular sweep relative to the magnitude of the first reflector's movement.

The small movement requirements of the first reflector enables the following benefits: compact design, low energy consumption, variable sweep frequency, no gyroscopic effect and a variable sweep angle.

BRIEF DESCRIPTION OF THE FIGURES

The present invention is described with the aid of the following figures:

Figure 1 is a diagram representing one embodiment of the invention.

Figure 2 is a diagram representing an embodiment of the invention using two fixed mirrors.

Figure 3 is a diagram representing the embodiment of Figure 2 where the directed propagation of electromagnetic radiation has a defined width, using rotational oscillation/vibration.

Figure 4 is a diagram representing another embodiment, projecting electromagnetic radiation with a defined width between a pair of fixed reflectors.

DETAILED DESCRIPTION

The invention presented here allows, using low amplitude moving reflector(s), simple and passive optical or reflector components, to double, triple, or more compared to the amplitude of a single reflection upon the moving reflector, according to the configuration of the device, the amplitude of the angular sweep of a directed propagation of electromagnetic radiation. For example a collimated or focused laser spot, without affecting its luminous power, may be swept in a wide angle with only a small magnitude angle variable moving reflector in the form of a mirror. The invention also has application with any form of directed electromagnetic radiation, for example: microwave energy, visible and non-visible light, infra-red, radar and radio waves, where an angular sweep of the electromagnetic radiation is desired.

According to figure 1, the electromagnetic radiation arrives from the left towards the movable (vibrating, oscillating) reflector, for example a mirror, having in this example, vibration in rotation of 6°. The fixed reflector, placed opposite that which vibrates, is located to intercept the electromagnetic radiation already angularly deviated to again return it towards the movable reflector, thus at least doubling with each reference the angular deviation (sweep). Without the fixed reflector, the resulting sweep would be an angular deviation of 12° by simple reflection on the movable reflector, Here, the two passes between fixed reflector and movable reflector raise the angular deviation to 36° peak-peak of the electromagnetic radiation at output.

The relative alignment of the fixed and movable elements can be in any configuration that returns the electromagnetic radiation to the movable reflector. Figures 2 to 4 demonstrate three alternative and non-exhaustive embodiments of the present invention that demonstrate the sweep range and level of compactness possible for a sweeping module constructed according to the present invention.

In figure 2, the vibration/oscillation of the movable reflector of 10°, gives 60° at output. The use of two fixed mirrors enables a reflection path optimized for a compact sweeping module. Figure 3, shows a similar layout applying rotational movement, one half the amplitude, accounting for the requirements of the electromagnetic radiation having a practical diameter. Taking again the provision of figure 2, the physical width of the directed propagation of electromagnetic radiation, for example a laser spot

(here of 1mm), compared to dimensions of the mirrors as drawn affects the amplitude of the resulting beam sweep.

Figure 4 demonstrates another embodiment, demonstrating that the fixed mirrors may be aligned on either side of the electromagnetic radiation source.

The specific orientation of the fixed reflector(s) about the movable reflector may be influenced by the type of oscillation/vibration/rotation mechanism used and desired constraints on the size and orientation of the sweeping module with respect to the radiation source. In the present invention, a fixed reflector is one that is not driven to oscillate, vibrate or otherwise rapidly change its angular orientation with respect to the first reflector. The fixed reflector(s) may be configured to be adjustable with respect to their distance from the first reflector, for example closer or farther from the first reflector adjustable along a track, the sweep angle can thereby be adjusted without requiring the first reflector's frequency to be changed - allowing the first reflector to remain at the resonance frequency. In a further embodiment, one or more of the fixed reflector(s) may be replaced with at least one movable reflector. The additional movable reflector, preferably oscillating or vibrating at a lower amplitude than the first reflector, creates a changing sweep angle. The sweep created by this embodiment, alternately moving between wide and narrow has the ability to, for example, scan machine readable symbologies at widely varying ranges from the sweep module without requiring operator adjustment of the device between scans.

The form of movable reflector oscillation/vibration/movement used does not alter the basic idea of the invention. Examples of alternative types of oscillation/vibration include: vibration around an axis of torsion, vibration in inflection, inductive vibration and vibration on an axis of the galvanometric type, in resonance or not.

Energy savings resulting from the reduction of the mechanical expenditure of energy according to the invention are a function of the reduced total mechanical action required. Where the reflectors are 100% reflective and planar, no loss is added by the passage between them and the beam diameter remains unchanged. The movable reflector having to move in a reduced way to obtain a satisfactory sweeping of the beam, there is a reduction in proportion of energy required for obtaining this movement. The mobile element no longer having a great amplitude, mechanical resonance can be abandoned with an actuator, thus authorizing, with reduced energy, an angular sweep at a controlled frequency and amplitude, including static pointing in a given direction (useful for targeting prior to initiating a scanning sweep).

A mechanical structure integrating, for example a laser, its collimator, a movable reflector and an optimized and compact optical provision of fixed reflectors makes it possible to obtain a compact module fulfilling the function of a sweeping laser spot in a reduced package size thereby creating ergonomic, energy consumption, manufacturing and materials cost efficiencies.

The present invention is entitled to a range of equivalents and is to be limited in application or scope only by the following claims.